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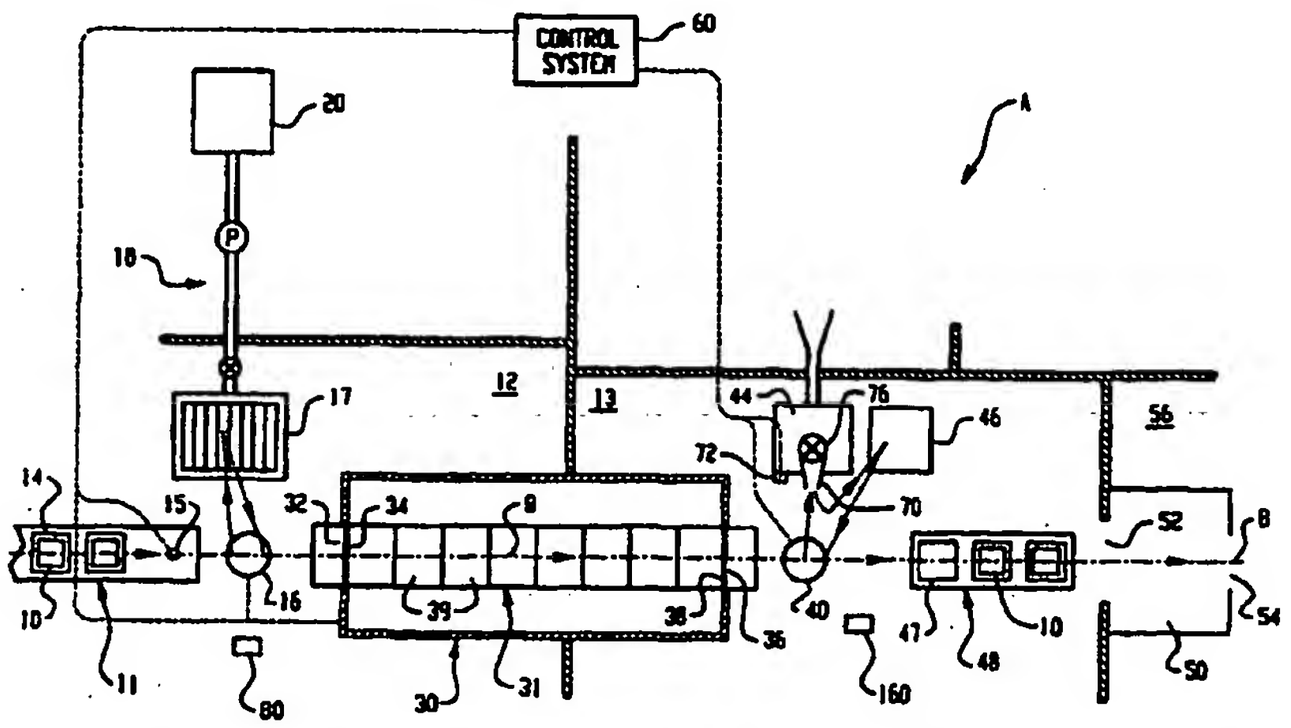
(54) Title: TRANSFER SYSTEM FOR ANIMAL CAGES, BASKETS, AND PALLETS



(57) Abstract: A conveyor system (11) delivers an assortment of items from an animal research facility, or the like. The items may include baskets, animal cages, pallets, or other items to be handled, which are delivered in a fairly random sequence. A sensor system (15, 90) detects what type of item is to be handled. An industrial robot (16) moves to a gripper changing station (80) to select an appropriate gripper (82) for handling the item, which is then connected to an arm (86) of the robot. The robot mechanically grips the item with the gripper, and if the item is one which needs emptying, inverts the item over a dump station (17) to empty soiled bedding or other waste. The robot then loads the emptied item onto a conveyor (31) of a washer (30) and the item is carried through an automatic cleaning process. At the other end of the cleaning process, a second robot (40) detects the position of the item. The robot carries the cleaned cages to a bedding station (44) to be refilled with fresh bedding and then places the filled cages on pallets on a further conveyor (48), which carries the cages to a loading area. Other items, such as baskets and pallets, are stacked on the conveyor.

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TRANSFER SYSTEM FOR ANIMAL CAGES, BASKETS, AND PALLETS

Background of the Invention

The present invention relates to the animal husbandry and cleaning arts. It finds particular application in connection with the automatic removal of dirty bedding from animal cages prior to cleaning and the subsequent refilling of the cages with clean bedding, and will be described with particular reference thereto. It should be appreciated, however, that the invention is also applicable to cleaning processes for other objects and to the automated transfer of a variety of receptacles and other items.

Animal testing laboratories and similar facilities typically have large numbers of animal cages to be emptied of dirty bedding, cleaned, and refilled with fresh bedding on a regular basis. The emptying, cleaning, and refilling process poses hazards to workers. The cages are generally contaminated with dirt and feces, which may be particularly hazardous as a result of diseases and medications associated with the caged animals. Additionally, allergens are frequently associated with the bedding which are released into the air on airborne particles of the bedding. Dust particles released from fresh bedding may also be hazardous.

To minimize exposure to these hazards during the cleaning process, it is desirable to provide an automated cage handling system which reduces operator handling of the cages. Operators are particularly susceptible to the hazards at two stages in the cleaning process, namely, during emptying the cages into a disposal system, and during refilling of the cages with fresh bedding.

At the clean side of the system, fresh bedding stored in a supply chamber or bulk bags is transported to a

dispensing station. This process often results in the release of airborne particles of bedding into the atmosphere.

Additionally, workers are likely to suffer health problems from the repetitive motions involved. Back injuries sometimes result from lifting baskets filled with water bottles, which may weigh up to about 20 Kg when filled with water. It is thus desirable to have these functions fulfilled by an automated device, such as a robot.

Currently available robots, which employ vacuum cups for picking up the items, are not able to turn the cages over without first placing them down on a surface. This adds an extra step to the handling process. Additionally, the bedding and other loose material in the cages can become trapped in the cup or hoses and prevent proper operation of the vacuum system.

The present invention provides a new and improved automated system and method for handling animal cages, baskets, pallets, water bottles, and the like, which overcomes the above-referenced problems and others.

Summary of the Invention

In accordance with one aspect of the invention, an automated handling system for transferring a plurality of items is provided. The system includes an industrial robot having an arm. The system is characterized by a plurality of interchangeable gripper assemblies each assembly being selectively connectable with the arm and configured for gripping at least one of the items therebetween. Each of the gripper assemblies including at least one movable member which moves relative to a second member for gripping the item therebetween. The robot is capable of selecting one of the assemblies according to a type of item to be handled.

In accordance with another aspect of the present invention, an automated method of handling a plurality of different items is provided. The method includes detecting an item to be handled and moving the item with an arm of an industrial robot. The method is characterized by selecting

a gripper assembly for handling the item from a plurality of interchangeable gripper assemblies. Each assembly is selectively connectable with the arm of the robot and configured for gripping at least one of the plurality of different items. The method further includes connecting the gripper assembly with the robot arm, manipulating the robot arm and the gripper assembly so that the gripper assembly grips the item, and moving the item with the robot arm.

One advantage of the present invention is that it provides an automated system for emptying and refilling animal cages with fresh bedding.

Another advantage of the present invention is that it handles a variety of shapes of items.

Another advantage of the invention is that the robot arm picks up a cage, turns it over and empties it, then places the cage on a conveyor system for the washer, without the need for placing the cage on a surface and gripping the cage in a second position.

Another advantage is that it reduces human exposure to dust, allergens, disease germs, and medicinals.

Still further advantages of the present invention will become apparent to those of ordinary skill in the art upon reading and understanding the following detailed description of the preferred embodiment.

Brief Description of the Drawings

The invention may take form in various components and arrangement of components and in various steps and arrangements of steps. The drawings are only for purposes of illustrating a preferred embodiment and are not to be construed as limiting the invention.

FIGURE 1 is a schematic diagram of a system for removal of bedding, cleaning, and refilling of animal cages according to the present invention;

FIGURE 2 is a perspective view of one embodiment of an interchangeable robot gripper arm, according to the present invention;

FIGURE 3 is a perspective view of the interchangeable robot gripper arm of FIGURE 2, with the outer casing removed;

FIGURE 4 is a side sectional view of the interchangeable robot gripper arm of FIGURE 2, with the outer casing removed;

FIGURE 5 is an enlarged perspective view of the interchangeable robot gripper arm of FIGURE 4;

FIGURE 6 is a schematic view of a robot, conveyor belt and gripper station according to the present invention;

FIGURE 7 is a perspective view of a pallet with the flanges of the gripper arm of FIGURE 2 positioned for passing through a slot in the pallet;

FIGURE 8 is a perspective view of the pallet with the flanges of a gripper arm rotated to a gripping position;

FIGURE 9 is a perspective view of the robot gripping the pallet of FIGURES 7 and 8;

FIGURE 10 is a perspective view of the gripper arm of FIGURE 2 receiving an inverted cage at the end of a conveyor;

FIGURE 11 is a perspective view of the robot fitted with a second embodiment of the gripper arm according to the present invention; and

FIGURE 12 is an enlarged perspective view of the second embodiment of the gripper arm.

Detailed Description of the Preferred Embodiments

With reference to FIGURE 1, a cage and bedding handling system **A** for cleaning and replenishing animal cages is shown. The system **A** also is adapted for handling and cleaning other items, such as baskets, pallets, and the like. Cages are typically formed from a transparent material, such as molded plastic. They typically have a base and side walls with two or more integrally formed carrying handles. The cages may be stackable and arrive on the conveyor stacked or singly. Items **10** to be cleaned, such as animal cages, follow the path of arrow **B** through the system **A** as they are first

emptied of dirty bedding, then cleaned, and refilled with clean bedding prior to sterilization of the refilled cage. The items may be a random assortment of different items, including cages, baskets, and the like.

A first conveyor system **11** brings the dirty cages **10** into a "contaminated" area **12** which is separate from a "clean" area **13**. Preferably, several cages **10** are stacked on a pallet or wagon **14** and arrive at the end of the conveyor where a sensor **15**, such as a light or laser sensor, mounted to the conveyor or adjacent thereto, detects what type of items are to be handled. In the case of cages, each pallet preferably includes an indicator, such as a slot, which is positioned on the pallet according to the type of cage to be handled, or a bar code or other machine readable code, which is readable by the sensor and which is specific to the type of item to be handled. Cages of different sizes or shapes may each have a specific indicator so that the item(s) to be handled are specifically identified. For items which arrive on a pallet **14**, the pallet is preferably shaped so that it will only accept one type of item. The pallet can then be permanently marked with an identifier and is not readily loaded with incorrect items by an operator. For items which are not loaded on a pallet, the items each have their own indicator.

The sensor registers the type of item to be handled and signals a first industrial robot **16**. The robot uses the information from the sensor to determine how the item should be handled and what type of processing is required, as will be described in greater detail herein. In the case of cages, the first robot takes each cage **10** individually to a tipping funnel, hopper, or other suitable dump station **17** and inverts the cage to tip dirty bedding and animal waste from the cage into the tipping funnel. The tipping funnel **17** forms part of a bedding disposal system **18**, which transports the dirty bedding to a dumpster **20** or other disposal system for disposal.

In the case of baskets (typically formed of wire mesh and having a wire cover), the basket may contain a water bottle, which is cleaned along with the basket. The robot inverts the basket prior to washing so that any remaining water in the bottle drains out.

The first robot **16** takes the emptied cages and other items, including pallets, and loads them into a washing system, such as a tunnel washer **30**, by placing them on a second conveyor system **31**. Alternatively, the cages are manually emptied over the tipping funnel by an operator and carried by hand to the washing system **30**.

The tunnel washer **30** has a first opening or load section **32**, for receiving dirty cages in the contaminated area **12**. The first opening is selectively closed by an inlet closure or door **34**. A second opening or unload section **36** to the tunnel washer, through which washed cages are removed, is located in the clean area **13**. The second opening is selectively closed by an outlet closure or door **38**. The washer may be of a continuous type or manually loaded and unloaded after each cycle. Preferably, the washer is of the indexing type. In this type of washer, the conveying system is divided into sections **39**. The robot loads items on to a first section and then the conveying system moves or indexes the item by one section and allows the robot to repeat the process and place another item on the conveyor. The washer registers where each section is through the tunnel as the sections move through. The washer preferably includes sequential stations for rinsing coarse debris, washing, disinfecting, rinsing, drying, and the like, through which each of the sections pass sequentially.

Once washed, the cleaned cages **10** are transported from the second opening **36** by a second industrial robot **40**. The first robot **16** signals the second robot in advance to inform the second robot **40** as to the type, number, and so forth of the items passing through the washer. The washer signals the second robot as to where these items are, by identifying where each of the sectors is in the washer, or

indicating when each of the sectors is about to arrive at the second opening. In this way, the second robot is ready to handle the items as soon as they arrive. The second robot carries the cleaned cages to a bedding dispensing station 44, where the cage is refilled with fresh bedding. The robot may invert the cage prior to refilling. For items, such as baskets, which include a water bottle, the basket is transported to a water bottle refilling station 46, where fresh water is inserted in a clean water bottle. The second industrial robot 40 places the refilled cages on a pallet 47 on another conveyor system 48 which transports the refilled cages to further processing areas or to a loading area. In one embodiment, the items are then transported to a sterilizer/ disinfector 50, e.g., a high temperature or steam sterilizer. The sterilizer 50 microbially decontaminates both the cage and the bedding, and optionally also the water bottle. The sterilizer has a first opening 52 in the clean area 13, for receiving the refilled cages, and a second opening 54 in a sterile area 56 for unloading the sterilized/disinfected cages. Once the cages have been sterilized/disinfected they are ready to be returned to an animal room or other facility where animals are returned to the cages.

As described above, the system is automated, minimizing contact of operators with the dirty cages and with the bedding, which may be contaminated with feces, diseases, and allergens. Clean bedding, prior to sterilization, may also contain dust which is released into the air from the bedding. A computer control system 60 preferably controls the operation of the robots and many other functions of the system, which will be discussed in greater detail below. The control system 60 may be associated with one or both of the robots 16, 40, or be a separate piece of equipment.

Preferably, the bedding dispensing station 44 is automated for delivery of the fresh bedding through a dispensing outlet 70 to the washed cages. The station 44 may include a detector 72 which recognizes the presence of a

clean cage beneath the outlet 70 and opens a valve 76 to deliver a selected weight or volume of bedding to the cage. For example, an auger is operated for a selected time to deliver the bedding. Alternatively, the station is manually operated by an operator. Preferably, the second robot 40 signals the bedding dispensing station 44 in advance to alert the station that a cage is on its way and may also provide information on the type of cage so that the station knows how much bedding to dispense, based on the size or other features of the cage.

To handle more than one type of item, the robots 16, 40 each have a selection of gripper arms, each gripper arm adapted to picking up a particular type of item. These interchangeable gripper arms are stored at a gripper changing station 80, which is readily accessible to the robot. The control system 60 is programmed with all the information needed to direct the robots, such as the type of gripper arm appropriate for each of the different items, the type processing required for each of the items (pallets may be loaded directly on the washer conveyor 31, cages are taken individually from a pallet are inverted over the tipping station, baskets are simply inverted, and so forth). Separate instructions are programmed for each robot, since the tasks are different at each end of the washer.

With reference to FIGURES 2-5, one embodiment of a gripper arm 82 is suited to handling items, such as pallets, which have an aperture of a convenient size and location which can be utilized by the gripper arm for picking up the item.

With particular reference to FIGURE 4, and reference also to FIGURE 6, the gripper arm 82 has an attachment member 84, which is used for connecting the gripper arm to an arm 86 of the robot 16. The arm of the robot can be pivoted or rotated to facilitate positioning of the gripper arm. The attachment member 84 is shaped for releasable connection with a mating end 88 of the robot arm and carries electrical signals and pressurized air to the

gripper arm. Optionally, the robot **40** includes a sensor **90** (see FIG. 6), such as a laser sensor, which detects the type of item **10** to be picked up from the conveyor **11**, as an alternative or in addition to positioning a sensor **15** on the conveyor **11**.

The computer control system **60** instructs the robot to select the appropriate gripper arm **82** from the adjacent gripper station **80**. The robot attaches the gripper arm to the end **88** of the arm **86** via the attachment member **84** and turns the robot arm **86** to face the item **10** to be picked up.

The gripper arm **82** includes a support portion **92**, which is connected at one end with the attachment member **84**, and a head portion **94**, connected with the other end of the support portion, which includes the sensing and manipulative features of the gripper arm.

A sensor **100** is positioned on the gripper arm head **94** for detecting the position of the item **10**. The sensor **100** system includes at least one laser beam generator and receiver combination **101** which directs a laser beam at the item for gauging the distance from the item. The robot arm does not need to detect the type of item to be handled, as this information has already been received from the conveyor sensor **15**. The robots uses the information from both sensors to position the gripper arm and then pick up the item. The robot arm **86** is rotatable and movable allowing the gripper arm to be placed in the correct position for picking up the item **10**. Alternatively, or additionally the gripper arm is rotatable relative to the robot arm at the attachment member. Preferably, the rotation of the robot arm or gripper arm allows the item to be rotated through at least 180° so that the item can be inverted without first placing the item on a surface.

In one embodiment, shown in FIGURES 7 and 8, the item **10** has an aperture or slot **102** suitably positioned in a wall **103** thereof to receive rotatable fingers **104** and **106**, which extend from the head **94** of the gripper arm **82**. FIGURES 7 and 8 show a pallet **10**, although other items may be

similarly handled. The slot **102** can be the same one used as an indicator for identifying the pallet, or may be a separate slot. In this embodiment, the items to be handled by the robot with the gripper arm **82** have an aperture of an appropriate size and an appropriate position for being accessed by the fingers **104** and **106**. The aperture may be formed, for example, by cutting a hole in the item, formed during molding a molded item, or may be an opening between crossing wires which form a cage.

With particular reference to FIGURE 4, the fingers **104** and **106** each include a flange, **108** and **110**, respectively, which is connected with a tubular portion or axle **114**. The flanges extend forwardly of the head **94**. The axles are received in bores **116** in the head of the gripper arm and are each able to rotate within the respective bore to rotate the flange relative to the head **94**. The bores are parallel with each other and with the support member **92** such that the flanges rotate in a plane generally perpendicular to the support member when the axles rotate. A motor **118** rotates the axles.

The aperture is shaped to receive flanges **108** and **110** when the flanges are positioned as shown in FIGURES 5 and 7. As shown in FIGURE 5, the flanges are in a generally horizontal position, such that tips **120** of the flanges furthest from the axles **114** face each other. In this position, the flanges pass through the aperture **102** in the item. Then, the motor rotates the finger axles **114** through approximately 90 degrees so that the flanges are positioned generally vertically as shown in FIGURES 4 and 8. (The left-hand flange rotates in one direction while the right-hand flange rotates in an opposite direction.) In this position, inner surfaces **122** of the flanges are able to contact an outer surface **124** of an adjacent wall of the item **10**.

A pair of engagement pins **130, 132** are positioned for engaging an inner surface **134** of the wall **103** so that the wall is gripped between ends **136** and **138** of the engagement pins and the corresponding, adjacent flanges **108, 110**. The

pins are received in corresponding parallel bores **140** in the head of the gripper arm such that the ends **136** and **138** of the pins protrude from the head. Optionally, replaceable rubber polymeric tips are mounted on the ends of the pins. The pins move out of and into the bore to adjust the gap between the pin ends **136, 138** and the tips **120** of the flanges, according to the thickness of the wall of the item. The pins are driven by a hydraulic cylinder or pneumatic cylinder, or other suitable drive mechanism **146** to grip the wall **103**. With the flanges in the vertical position (i.e., with their tips in line with the pins), the pins are moved forward of the head to apply a predetermined amount of force which is known to be sufficient to grip the wall properly, without damaging the item.

The item **10** is thus held firmly by the gripper arm **82**. The control system **60** then operates the robot arm so that the item is moved in the appropriate manner (see FIGURE 9). For example, cages are carried by the robot arm to the bedding dump station **16**. The robot arm rotates to invert the cage and the used bedding is tipped into the dump station. The robot arm **86** carries it in the inverted position to the wash conveyor **21** or may reinvert the cage before placing it on the washer conveyor. When the item is positioned over the conveyor, the gripping process is reversed- i.e., the pins are retracted and the flanges rotated from the vertical position to the horizontal position so that the item **10** is released from the gripper arm **82** and drops onto the conveyor in an appropriate position. The conveyor carries the item into the washer **30**.

Optionally, the sensor **15** or **90** detects if there is a water bottle in the cage **10**. If a water bottle is present, the computer control system directs the robot to position the cage in an inverted position on the conveyor belt **21** so that the water in the water bottle drains from the bottle.

After washing is complete, the conveyor **31**, or a separate conveyor, carries the item **10** out of the washer **30**. The second robot **40** then takes over the manipulation of the

item. Preferably, the second robot is provided with information about the items passing through the washer so that it has already obtained an appropriate gripper arm from a suitably positioned gripper station **160** when the item **10** is ready to be picked up. Alternatively, the second robot uses a sensor similar to the sensor **90** of the first robot for identifying the type of item to be picked up. Preferably, the first robot signals the type of item(s) in advance and the washer signals when the sector on which the item(s) is located is due to arrive so that the second robot is ready to handle the item(s) when it exits the washer.

The robot uses a gripper arm, which is analogous to the gripper arm **82** used by the first robot, to pick up the cleaned item in the same manner as previously described. If the item **10** is a cage, the control system **60** instructs the robot to fill the cage with fresh bedding at the bedding dispensing station **44**. The robot holds the cage beneath the dispenser while the bedding is dispensed, then carries the cage to the conveyor **48** where the cage may be placed on top of a stack of already filled cages on a pallet for transporting elsewhere in the facility.

Often, the position of the cage **10** on the conveyor belt **21** shifts slightly as it passes through the washer. To ensure that the cages are stacked correctly one on top of the other, the sensor **90** or **100** on the second robot detects the shift in position and accommodates for the shift when stacking the cage in the stack.

The gripper arm **82** grips the item **10** with sufficient force that the item can be turned, inverted, emptied, filled with bedding, and the like without the need to place the item on a support surface or to change the position of the gripper arm on the item. This allows each of the steps to be completed quickly, in rapid sequence, without wastage of time for repositioning the gripper arm on the item. At the end of a transfer procedure, the robot either returns the gripper arm **82** to the gripper changing station

or, if a similar item is to be handled next, keeps the gripper arm in place for the next procedure.

With reference now to FIGURE 10, an alternative method of using the gripper arm **82** is illustrated. Here, the item to be manipulated is a cage or other plastic item in the shape of a container which does not have a suitably shaped aperture **102**. The flanges **108, 110** of fingers **104, 106** are positioned on one side of a wall **176** of the container, with a lip **180** of the container resting on a support portion **182** of the head. The support portion carries the bores **116** therethrough for the axles **114** and spaces the flanges of the fingers from the pins when the pins are retracted. The fingers need not be rotated in this embodiment, since there is no aperture through which they must pass, although it may be preferable to have the flanges in the horizontal position to allow them to pass more easily under the cage. As the cage **10** reaches the end of the conveyor **11** (or leaves the washer) it is lifted slightly, by a moving serrated belt **190** so that the fingers can pass under the lip **180** of the wall of the container to be gripped. The belt has a number of stepped portions **192**. The lip rests on one of the stepped portions and is thus held slightly above the conveyor, providing room for the fingers to pass under the lip as the gripper arm moves towards the cage. The pins **130, 132** are actuated by the motor to grip the wall of the container **10**, as previously described.

With reference to FIGURES 11 and 12, a second embodiment of a gripper arm **200**, suitable for picking up baskets is shown. The gripper arm **200** is interchangeable with the gripper arm **82** and is selected by the robot when a basket is to be manipulated. The basket gripper arm **200** is connected to the robot arm and released therefrom in the same manner as previously described for the gripper arm **82**.

The basket gripper arm grips the outside of the basket between two arms **202** and **204**. The arms form parallel sides of a U-shaped member which is connected to the robot arm **86** through a releasable connecting member **84'** similar to

member 84. The U-shaped member has a top portion 206 which is connected to member 84'. The arms 202, 204 extend forwardly of the top portion to grip the basket. Arm 202 is a stationary arm while arm 204 is a movable arm. The top portion 206 includes a telescoping portion 207 which allows the distance between the two arms to be varied for accommodating different size baskets by moving the movable arm closer to, or further away from the connecting member 84'.

Distal ends of the two arms include gripping portions 210, 212 which are shaped to grip the basket snugly. Preferably, the gripping portions include pins 213 or other protrusions which engage suitably placed apertures in the basket when the two arms are brought together to grip the basket. Preferably a series of pins are provided, which engage one or more of the basket's apertures. This is to accommodate variations in the positioning of the basket or shape of the basket. Alternatively, pins or protrusions on the basket are received by apertures in the gripping portions.

The computer control receives measurements of the force applied to the basket and adjusts the telescoping portion using a hydraulic piston 214, or other suitable motor driven device, for adjusting the length of the telescoping portion.

The gripper arms of the embodiments shown is able to handle larger weights than previous arms-typically up to about 60 kilograms (which includes the weight of the gripper -somewhere between about 10 and 15 Kg), as compared with a maximum of about 10 kg for the vacuum cup-type robot systems.

A variety of different shaped items can be accommodated by the interchangeable grippers. Although two gripper arms have been described, it should be appreciated that any number of gripper arms may be employed, each gripper arm configured for handling at least one of the different items. Each of the items to be processed is capable of being handled by at least one of the gripper arms.

Having thus described the preferred embodiments, the invention is now claimed to be:

1. An automated handling system (A) for transferring a plurality of items (10), the system comprising an industrial robot (16, 40) having an arm (86) and characterized by:

a plurality of interchangeable gripper assemblies (82, 200) each assembly being selectively connectable with the arm and configured for gripping at least one of the items therebetween, each of the gripper assemblies including at least one movable member (130, 132, 204) which moves relative to a second member (104,106,202) for gripping the item therebetween, the robot being capable of selecting one of the assemblies according to a type of item to be handled.

2. The system of claim 1, further characterized by:

in a first of the gripper assemblies (82) the at least one movable member including at least one pin (130, 132) and the second member including at least one finger (104,106), the finger and pin cooperating to grip the item therebetween.

3. The system of claim 2, further characterized by the at least one finger including a pair of fingers (104,106).

4. The system of claim 3, further characterized by the fingers (104,106) being rotatable.

5. The system of claim 4, further characterized by the fingers (104,106) each including an axle (114) and a flange (108, 110), which extends forwardly of the axle, the axles being rotatable between a reduced profile orientation and an increased profile orientation in alignment with the pin (130, 132) for cooperation with the pin to grip the item.

6. The system of any one of preceding claims 2-5, further characterized by the pin (130, 132) being operable to move longitudinally relative to the finger (104, 106) to reduce a gap between the pin and the finger, a portion of the item being positioned in the gap.

7. The system of claim 6, further characterized by a source of pressurized fluid (146) for applying a force to extend the pins.

8. The system of any one of preceding claims 1-7, further characterized by a sensor (15) which detects a type of item (10) to be handled and instructs the robot (16, 40) to select an appropriate gripper assembly (82, 200) for handling the item.

9. The system of claim 8, further characterized by the sensor being mounted adjacent a conveyor system (11) which transports the item to the robot.

10. The system of any one of preceding claims 1-9, further characterized by the robot arm being pivotable and rotatable for positioning the gripper assembly in a suitable position for gripping the selected item.

11. The system of any one of preceding claims 1, and 8-10, further characterized by a second of the gripper assemblies including a fixed arm (20) and a telescoping arm (204), the telescoping arm cooperating with the fixed arm to grip an item therebetween.

12. The system of claim 11, further characterized by gripping ends (210, 212) of the arms including protrusions (213) which are received through apertures in the item.

13. The system of any one of preceding claims 1-12, further characterized by:

a conveyor (11) which conveys the items to the robot (16);

a hopper (17) into which the robot empties debris from the items; and

a washer (30) into which the robot places the items.

14. The system of claim 13, further characterized by:

a second robot (40) which removes washed items from the washer;

a filler (44,46) to which the second robot carries each item to receive a filler material.

15. The system of claim 14, further characterized by:

a disinfector/sterilizer (50) towards which the second robot directs each of filled items.

16. The system of either one of claims 14 and 15, further characterized by the items being animal cages, the debris including soiled bedding, and the filler material being fresh bedding.

17. The system of claim 16, further characterized by the animal cage being of plastic and at least one of the gripper assemblies including:

a stop (108, 110) that is positioned on one side of a wall (176) of the cage; and

a pin (130,132) which is longitudinally advanced with a preselected force to grip the cage side wall between the pin and the stop.

18. The system of any one of preceding claims 2-10 and 13-17, further characterized by the item having an aperture (102) defined therein and the finger (104, 106) being rotatably mounted on the gripper assembly to rotate between a reduced profile orientation to facilitate passing

through the aperture and an increased profile orientation in alignment with the pin (130,132).

19. The system of any one of preceding claims 1-18, further characterized by a sensor (15) which detects a type of item to be handled, the robot selecting a gripper assembly according to the type of item detected.

20. An automated method of handling a plurality of different items, the method comprising detecting an item (10) to be handled and moving the item with an arm (86) of an industrial robot (16,40), the method characterized by;

selecting a gripper assembly (82, 200) for handling the item from a plurality of interchangeable gripper assemblies, each assembly being selectively connectable with the arm of the robot and configured for gripping at least one of the plurality of different items;

connecting the gripper assembly with the robot arm;

manipulating the robot arm and the gripper assembly so that the gripper assembly grips the item;

moving the item with the robot arm.

21. The method of claim 20, further characterized by the gripper arm including at least one movable member (130, 132, 204) and at least one other member (104, 106, 202) and wherein the step of manipulating includes:

moving the movable member towards the other member to grip the item between the movable member and the other member.

22. The method of either one of preceding claims 20 and 21, further characterized by the gripper arm including a pin (130, 132) and a pair of rotatable fingers (104, 106), and wherein the step of manipulation includes:

rotating the fingers from a first position, in which flanges of the fingers are aligned, to a second position in which the flanges are positioned for gripping the item; and

gripping the item between the pin and the flanges.

23. The method of claim 22, further characterized by, prior to the step of rotating the fingers:

with the flanges horizontally aligned, advancing the fingers through an aperture (102) in the item, the aperture being sized to receive the flanges therethrough in the first position, the flanges contacting an adjacent wall of the item in the second position.

24. The method of any one of preceding claims 20-23, further characterized by the item being an animal cage and further including, with the robot arm and gripper assembly:

carrying the cage to a dump station (17);

at the dump station, emptying soiled bedding from the cage;

carrying the cage to a washer (30); and

washing the cage.

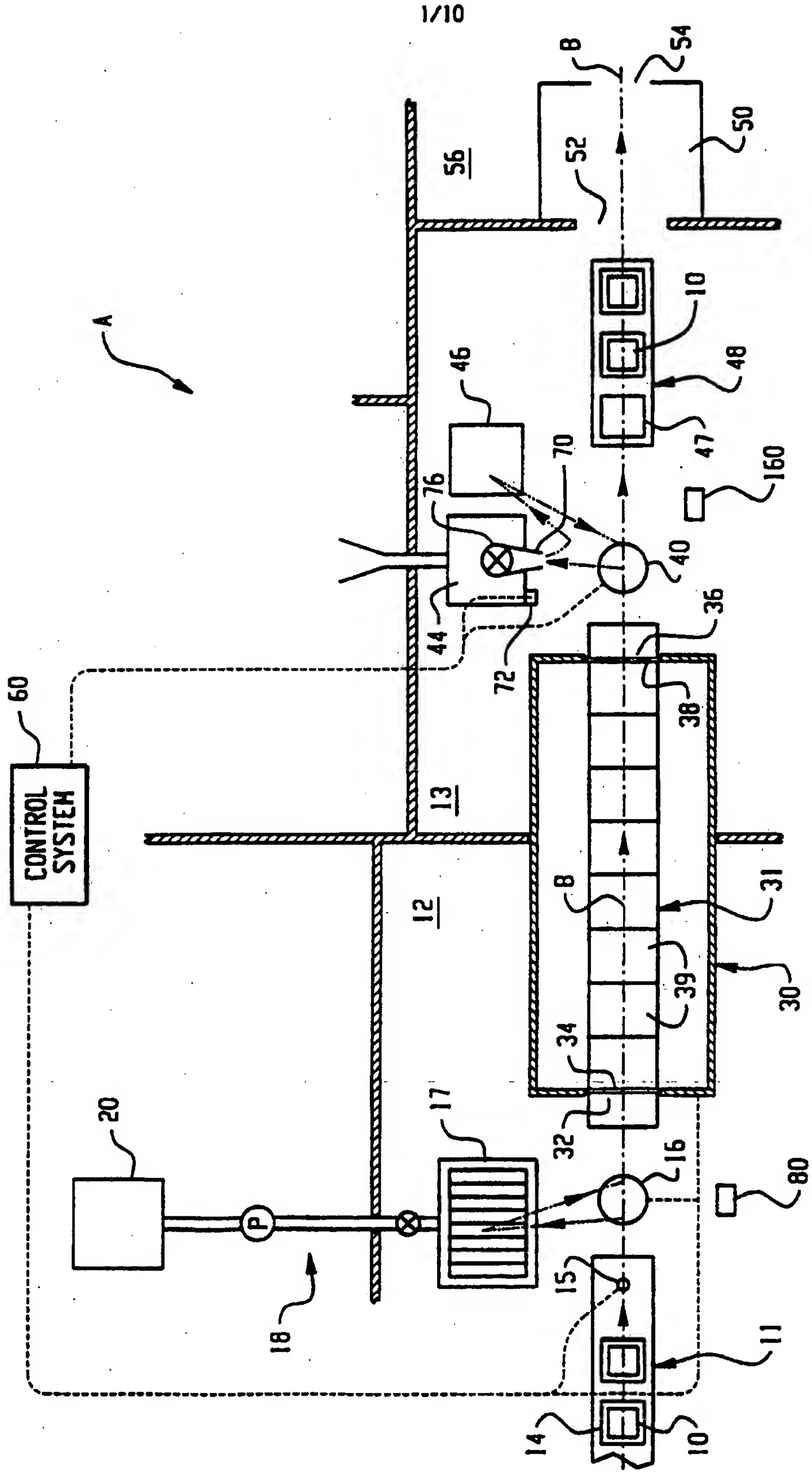
25. The method of claim 24, further characterized by, with a second industrial robot (40):

removing the cage from the washer; and

filling the cage with fresh bedding.

26. The method of claim 25, further characterized by:

sterilizing the cage filled with fresh bedding.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CONTROL SYSTEM
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Fig. 1

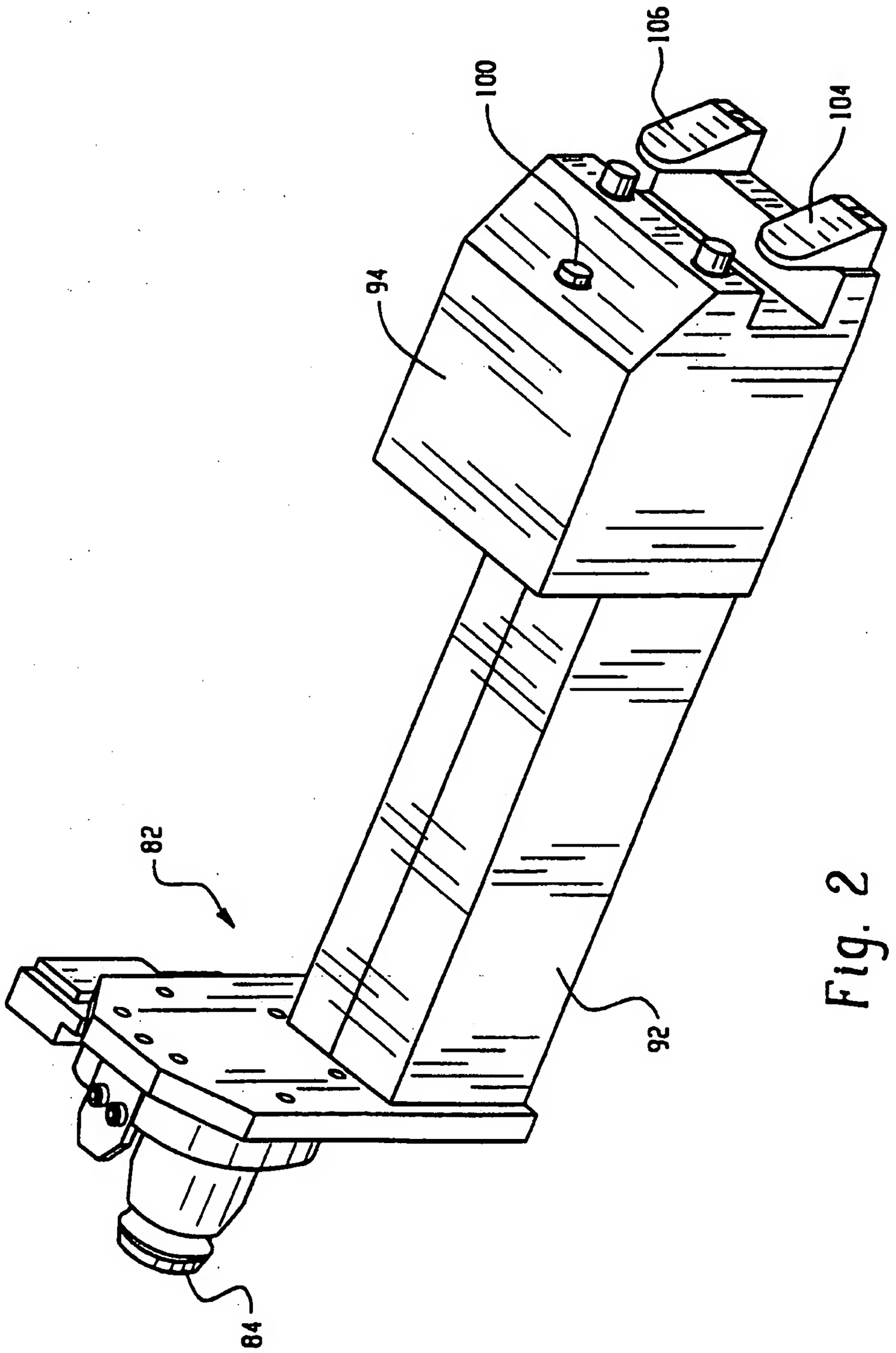
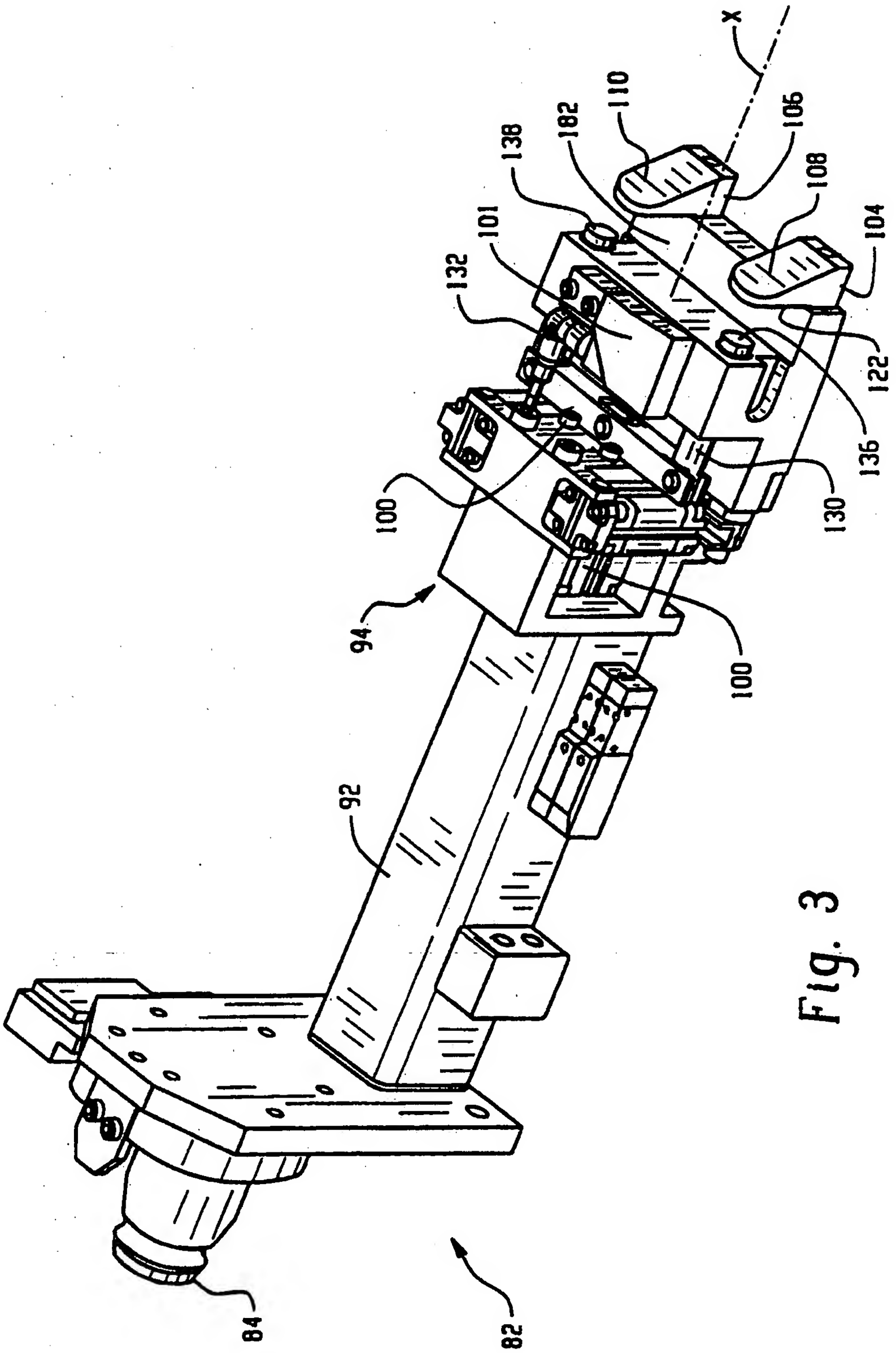


Fig. 2



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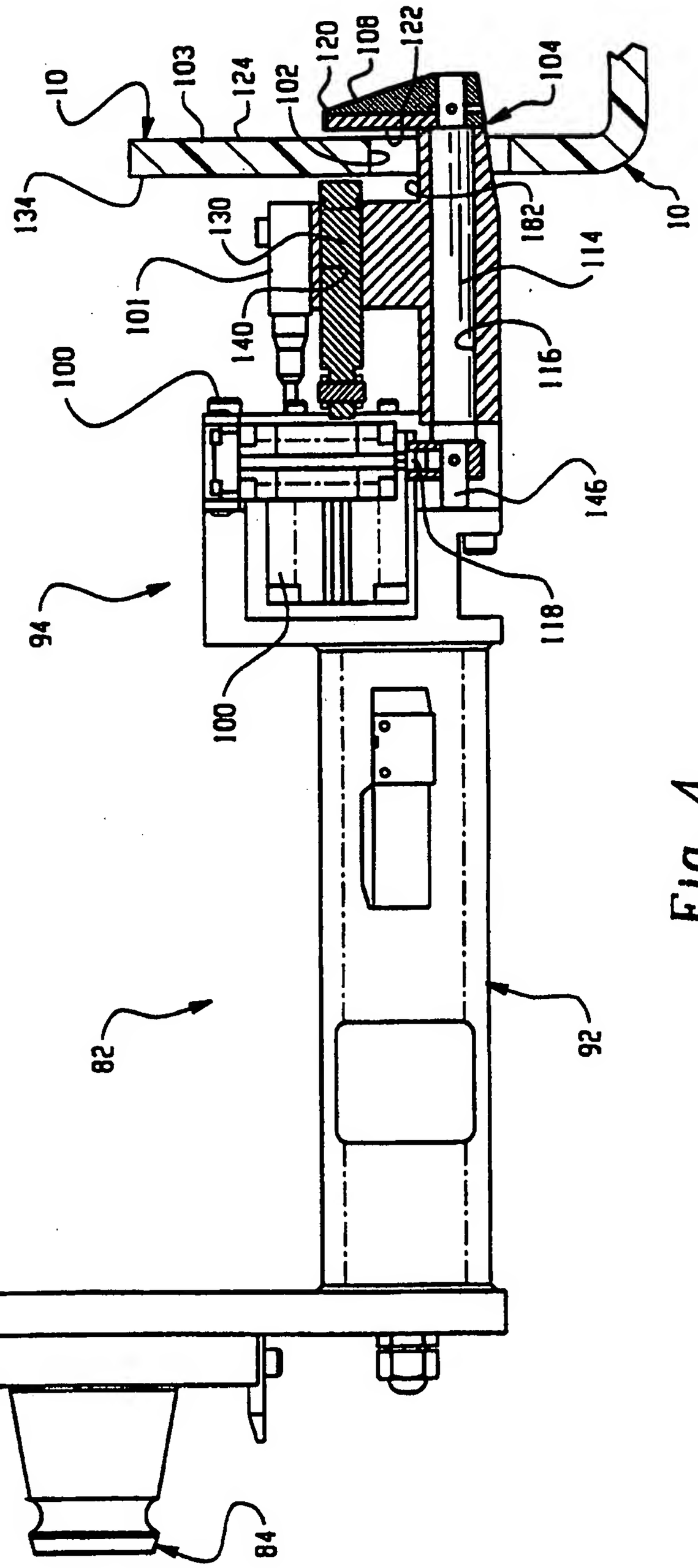
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Fig. 4

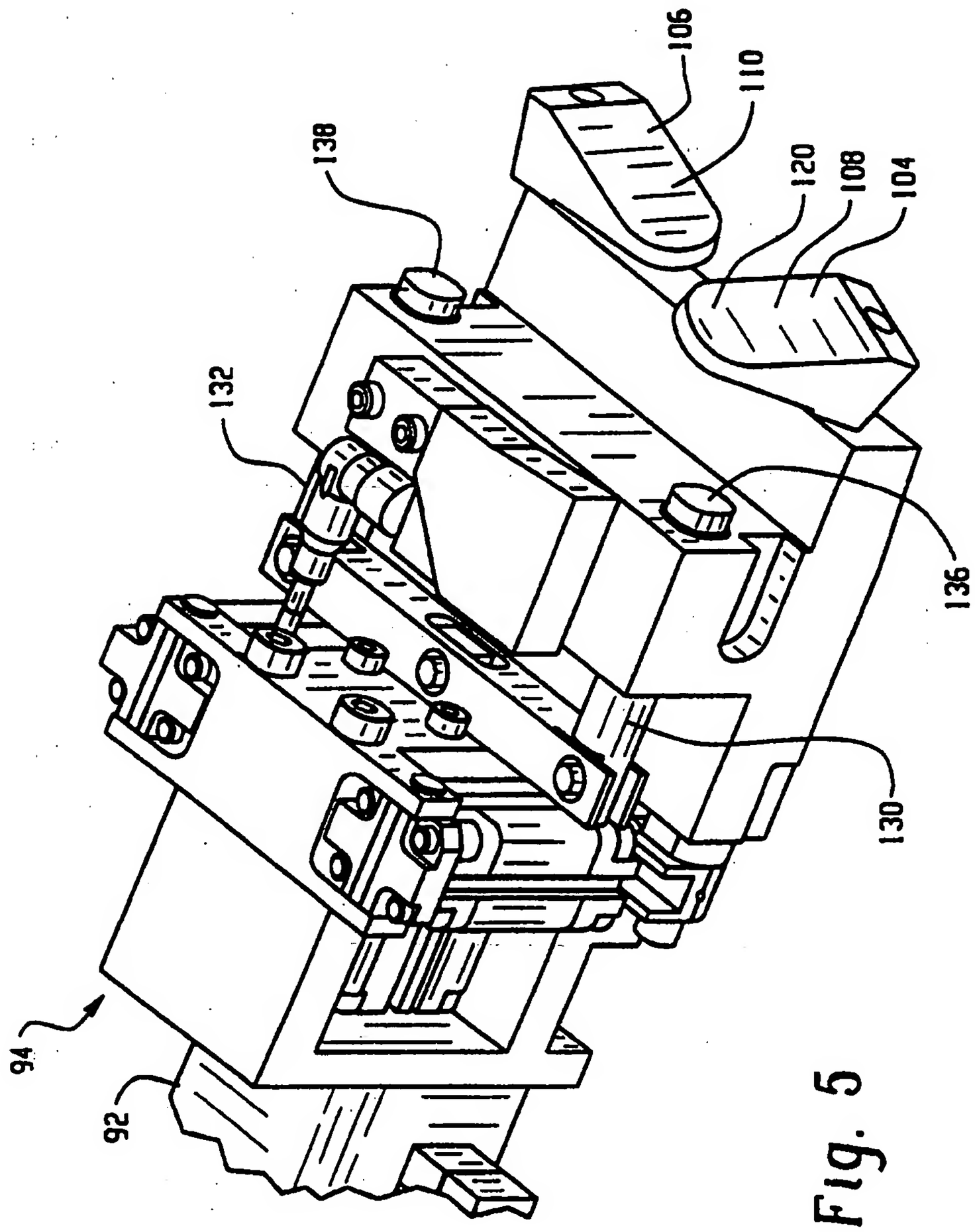
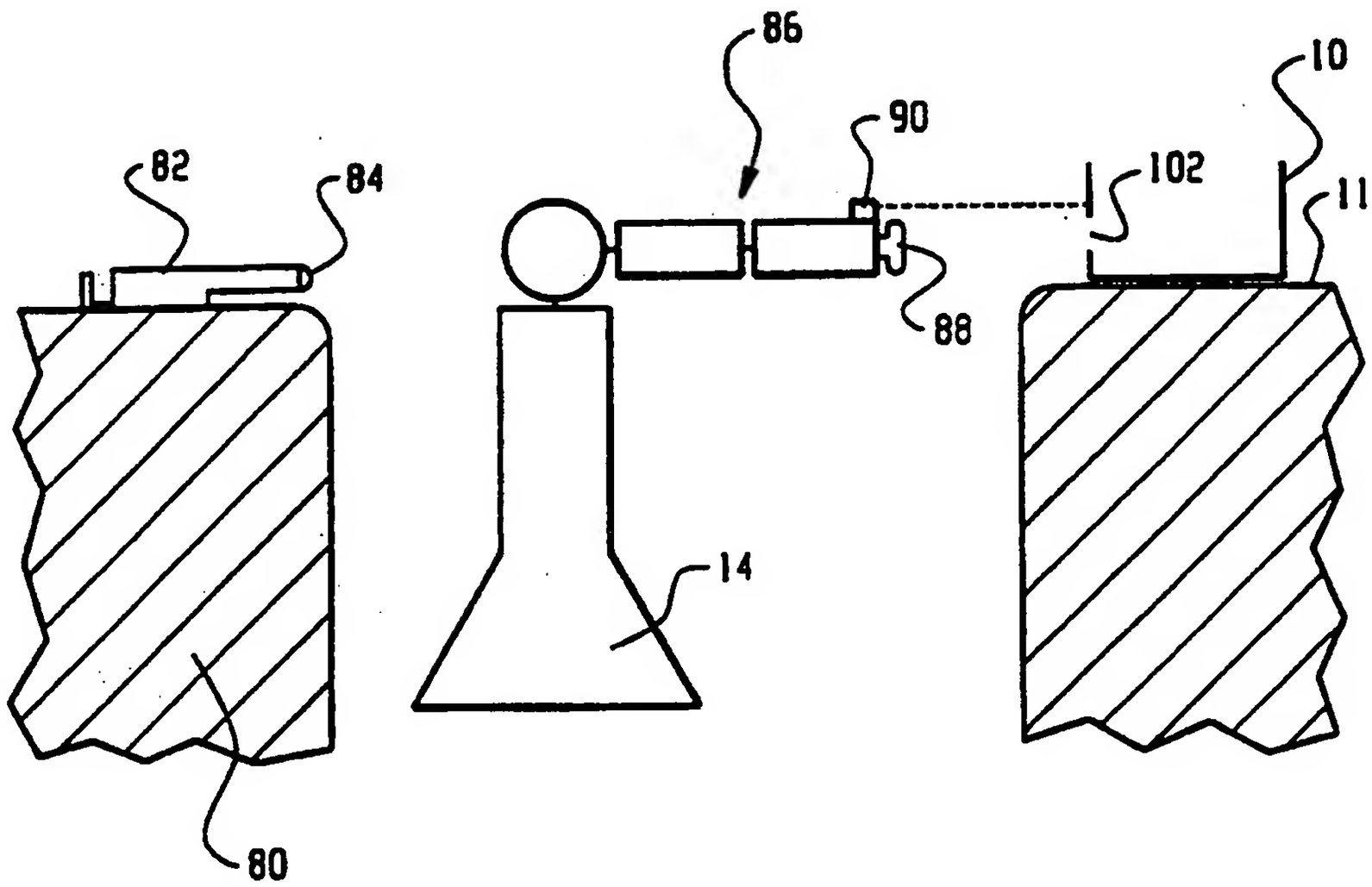


Fig. 5



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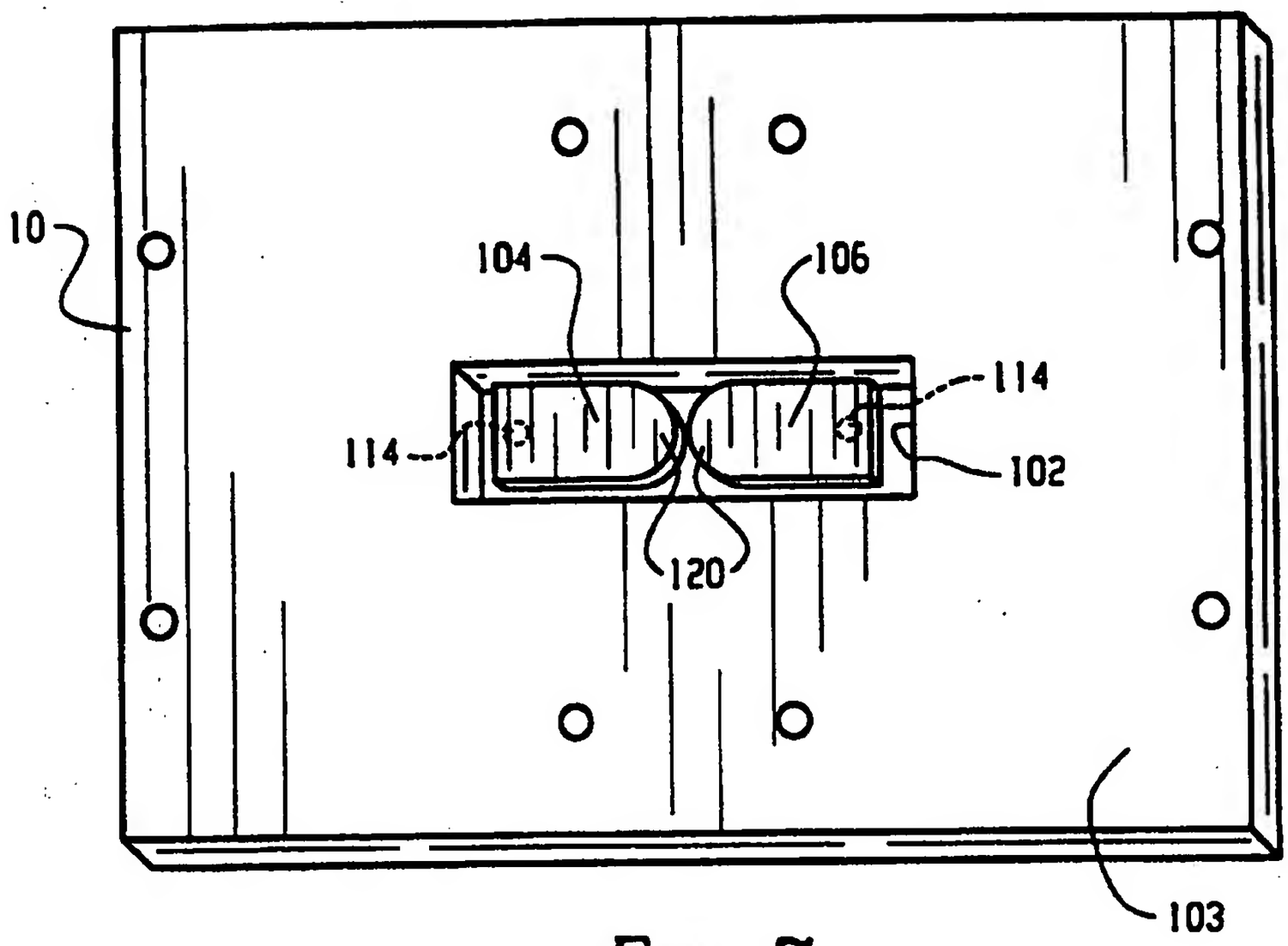

Fig. 7

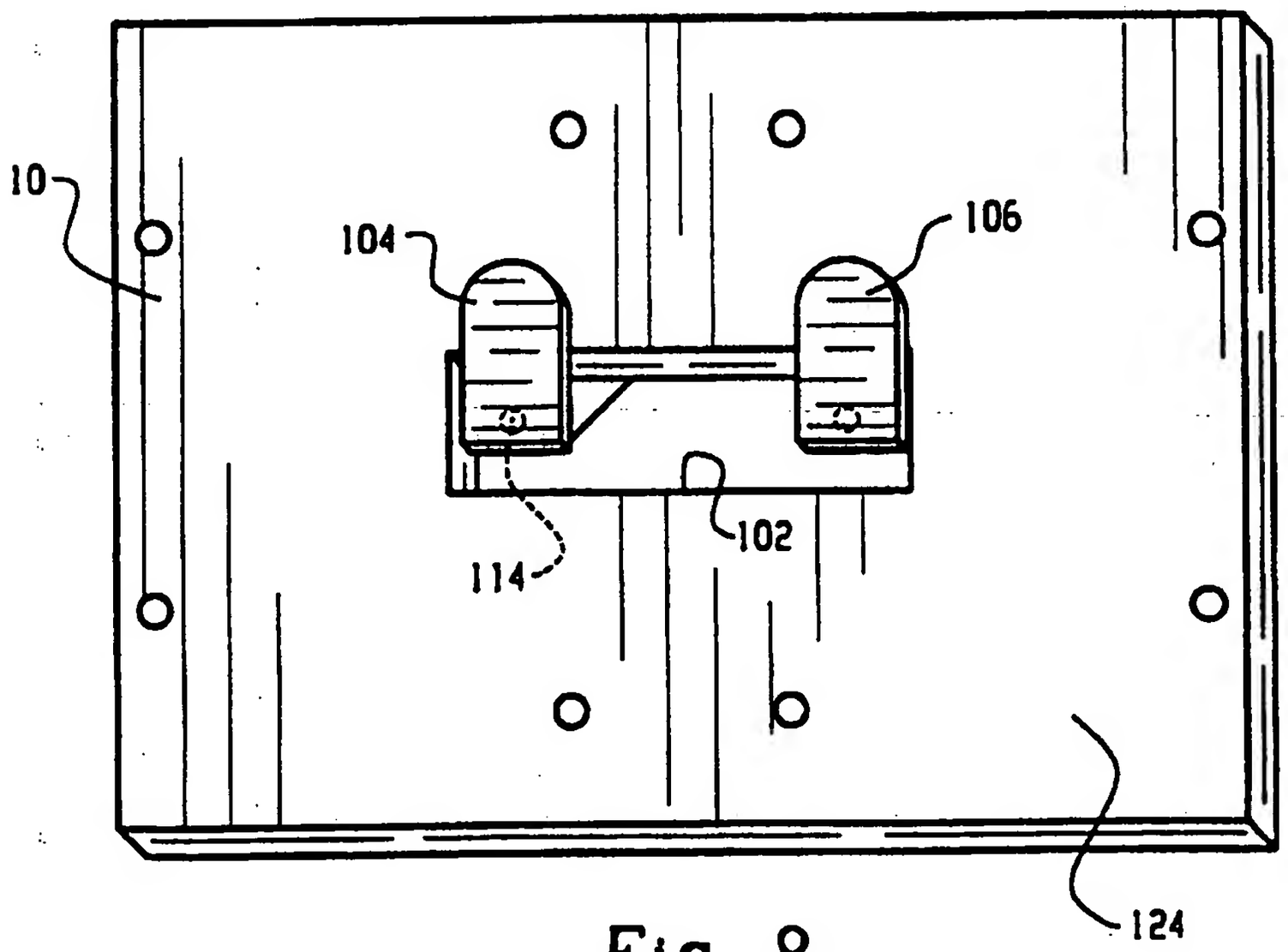

Fig. 8

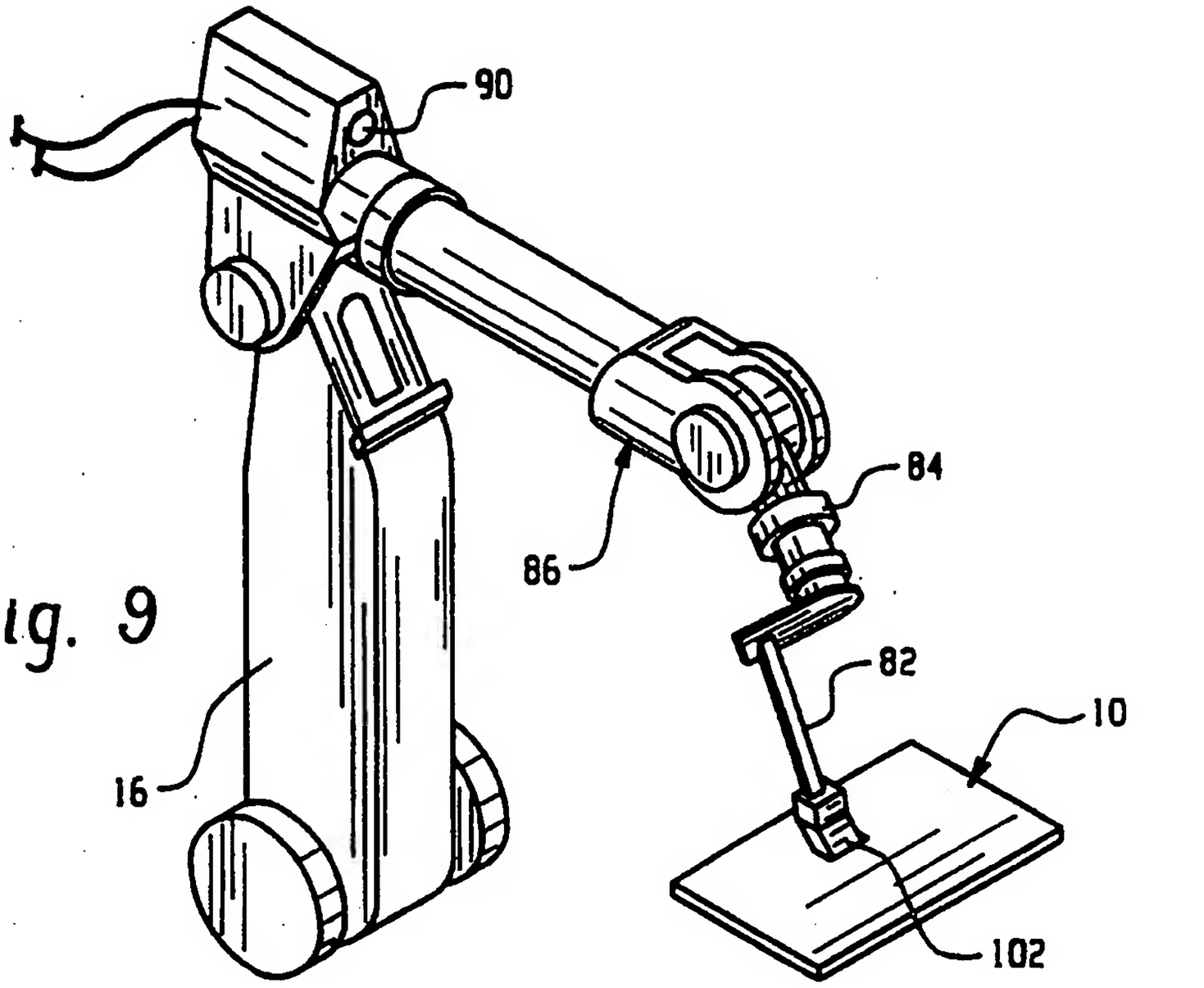

Fig. 9

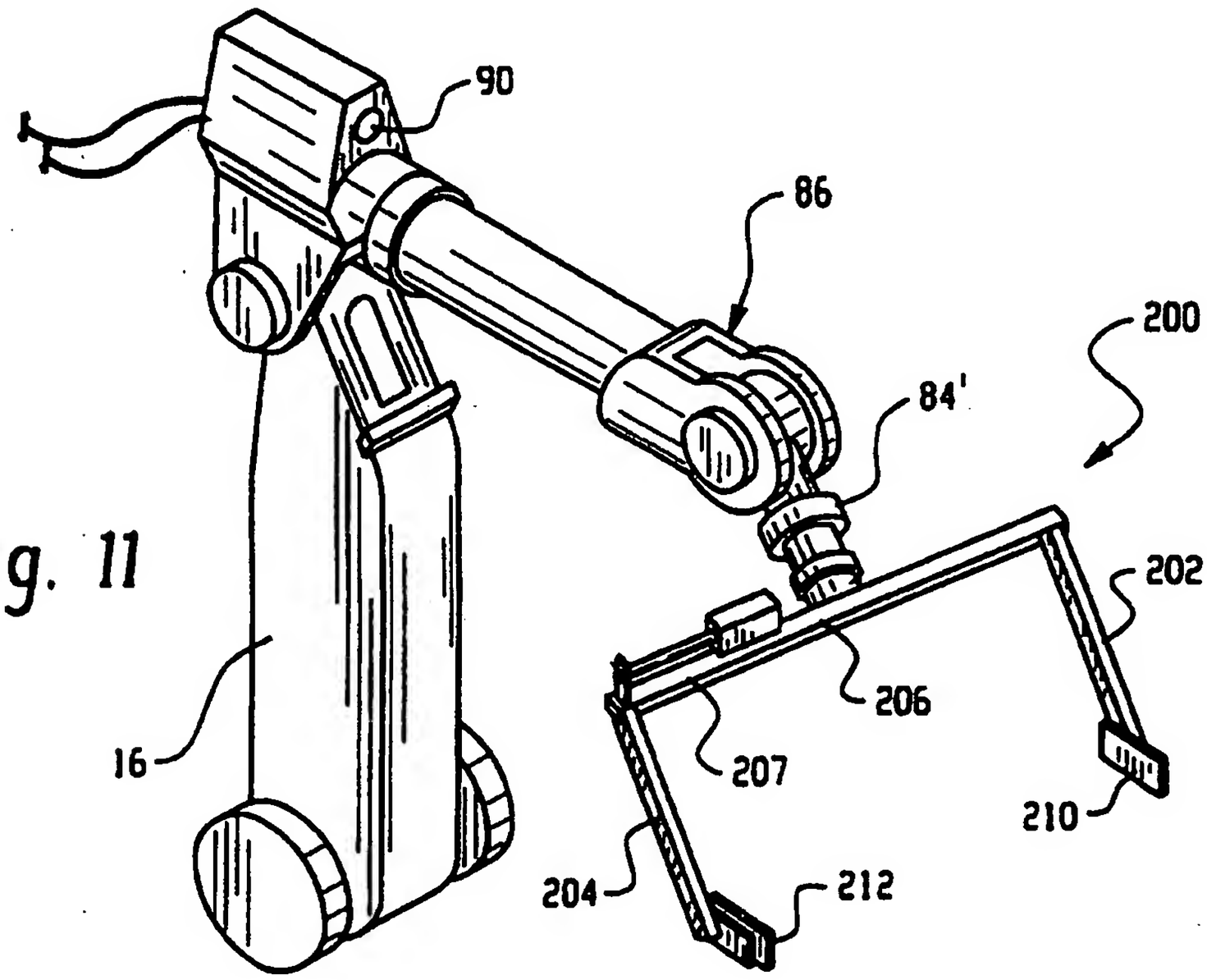

Fig. 11

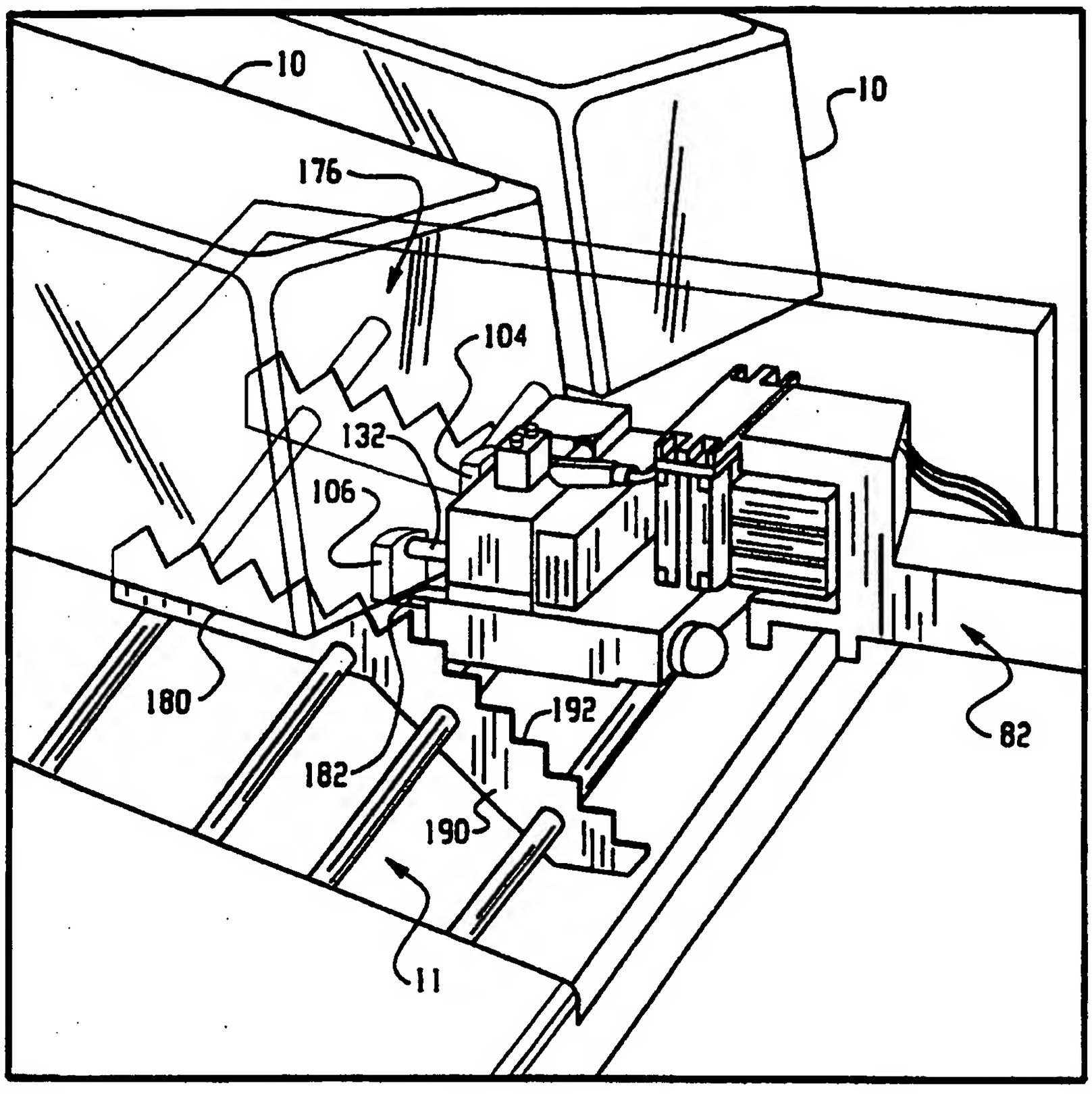

Fig. 10

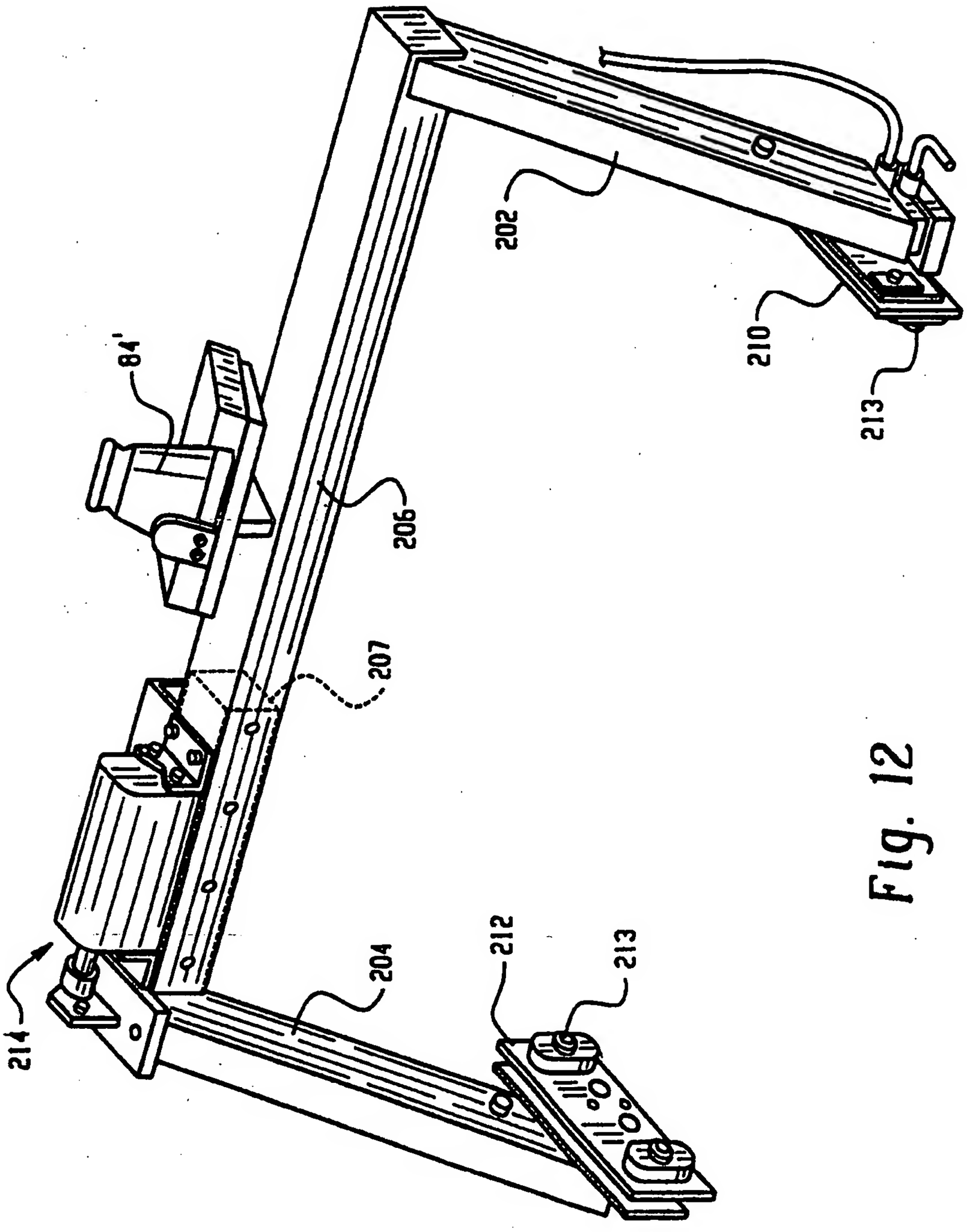

Fig. 12

INTERNATIONAL SEARCH REPORT

Intern. al Application No
PCT/US 00/27007

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 A01K1/03 B25J15/10 B25J15/02 B66C1/66 B08B9/08

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 B25J A01K B66C B08B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 58 211876 A (MATSUSHITA ELECTRIC INDUSTRY IND CO LTD) 9 December 1983 (1983-12-09) figure 2	1,8-10, 19-21
Y		2,3,6,7, 11
Y	PATENT ABSTRACTS OF JAPAN vol. 017, no. 286 (M-1422), 2 June 1993 (1993-06-02) & JP 05 016087 A (FUJITSU LTD), 26 January 1993 (1993-01-26) abstract; figure 1	2,3,6,7

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
8 January 2001	17/01/2001

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Lumineau, S

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INTERNATIONAL SEARCH REPORT

Intern ıal Application No
PCT/US 00/27007

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
Y	PATENT ABSTRACTS OF JAPAN vol. 011, no. 006 (M-551), 8 January 1987 (1987-01-08) & JP 61 183016 A (OKURA YUSOKI CO LTD), 15 August 1986 (1986-08-15) abstract; figure 1	11
A	PATENT ABSTRACTS OF JAPAN vol. 017, no. 008 (M-1350), 7 January 1993 (1993-01-07) & JP 04 240085 A (NISSAN MOTOR CO LTD), 27 August 1992 (1992-08-27) abstract; figures 1,2	2-5,18, 22,23
A,P	WO 00 45631 A (STERIS INC) 10 August 2000 (2000-08-10) the whole document	13-17, 24-26

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Information on patent family members

Intern al Application No
PCT/US 00/27007

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JP 05016087 A	26-01-1993	JP 2648794 B	03-09-1997
JP 61183016 A	15-08-1986	JP 1638345 C JP 3002781 B	31-01-1992 16-01-1991
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